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Waterborne Disease Outbreaks in Individual Water Systems in the United States, 1920-80

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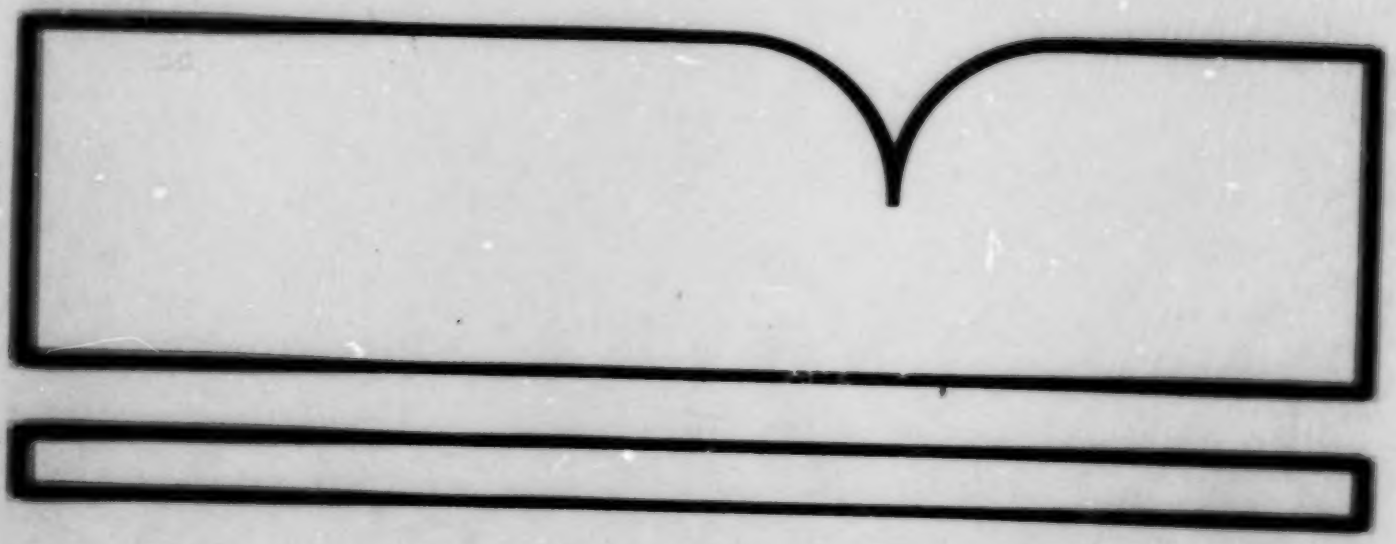

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WATERBORNE DISEASE OUTBREAKS IN INDIVIDUAL WATER SYSTEMS IN THE UNITED STATES, 1920-80

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16. ABSTRACT

An analysis of the etiologies and causes of 302 waterborne outbreaks occurring in individual water systems during 1920-80 showed S. typhi to be the most commonly identified pathogen and use of contaminated, untreated well water the major cause of these outbreaks. These outbreaks resulted in 6701 illnesses and 224 deaths and occurred primarily during June, July, August, and September.

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Since 1920 data on waterborne outbreaks have been compiled by various Federal agencies and individuals from reports and records of state and local health departments. Information on each of these reported outbreaks was evaluated and used to prepare this summary. Although previous summaries[1-5] of waterborne outbreaks are available for various time periods since 1920, outbreaks in individual water systems have not received as much attention as outbreaks in other water systems. By combining the data over this entire period an adequate analysis of the causes and etiologies of outbreaks is possible for these water systems. Outbreaks associated with water used or intended for drinking or domestic purposes and outbreaks associated with the use of contaminated springs and creeks by backpackers and campers were included.

The waterborne outbreaks in this summary are those where drinking water has been epidemiologically implicated as the vehicle of transmission of the illness. In most of the outbreaks the water was found to be bacteriologically or chemically contaminated but in only a few outbreaks was the etiologic agent isolated from both drinking water and clinical specimens. To be considered an outbreak at least two cases must be reported so that a common source can be noted and investigated. Except in unique circumstances, such as a case of chemical poisoning in which the chemical is identified in the water source, a single case of illness cannot be recognized as having been caused by drinking water. Single cases of infantile methemoglobinemia associated with high nitrate concentrations in water have been included in this reporting system only since 1979.

The water systems affected were classified as community, noncommunity, and individual. Community and noncommunity systems are defined according to provi-

sions of the Safe Drinking Water Act (P.L. 93-523). Water systems serving communities, subdivisions, and trailer parks having at least 25 year-round residents or 15 service connections used by year-round residents were classified as community water systems. Noncommunity water systems are those that cannot be classified as community systems but serve an average of at least 25 individuals for 60 or more days during the year. Individual water systems are used by year-round residents in areas without community systems or by persons traveling outside of populated areas (eg. backpackers, campers) where there are no noncommunity systems.

During the period 1920-80, 1405 waterborne outbreaks and 386,144 cases of illness were reported; 1084 deaths were associated with these outbreaks (Table 1). There has been a pronounced increase in the number of waterborne outbreaks reported recently, and the average of 39 outbreaks per year reported during 1976-80 is the same as reported during 1941-45 (Figure 1). This compares with an average of 25 waterborne outbreaks per year reported during 1971-75, 12 per year reported during 1951-70, and 23 per year reported during 1920-35. Because the reporting system is voluntary, differences in the occurrence of outbreaks over this time period must be largely attributed to differences in surveillance and reporting activities of the state and local health departments. Since 1971 the Environmental Protection Agency and the Centers for Disease Control have cooperated with state and local health departments in the investigation and reporting of waterborne outbreaks, and it is felt that the increased number of recently-reported outbreaks is primarily the result of more active surveillance. This cannot be quantified at present, and although reporting has generally improved since 1971, more waterborne outbreaks occur than are reported through this surveillance system. Reporting depends upon many factors, including the

type of water system, severity of disease, number of individuals affected, and interest and capabilities for recognition and investigation of the State and local level. For example during 1971-80, officials in Pennsylvania increased waterborne disease surveillance activities which resulted in the reporting of more outbreaks than any other state. Twenty percent of all waterborne outbreaks documented in the United States during this period were reported by Pennsylvania compared to 3 percent during 1941-70 and 11 percent during 1920-40. During a two-year period of increased staffing and improved waterborne disease surveillance in Colorado in 1980-82, eleven waterborne outbreaks were reported compared to a total of six reported during the previous three-year period. The large number of waterborne outbreaks reported during 1941-50 can be attributed primarily to the active surveillance program conducted in New York during this period, as this state accounted for 46 percent of all waterborne outbreaks reported during that period. Previously during 1920-40, eighteen percent of all waterborne outbreaks were reported by New York, and afterward during 1951-80 only 7 percent of all outbreaks were reported by New York. Outbreaks in community water systems, which number about 59,000 and serve about 180 million people, are probably the most likely to be reported. Outbreaks in noncommunity systems, which number about 240,000 and serve about 20 million people, primarily transients, are the next most likely to be reported. The least likely to be reported are outbreaks in individual water systems, which serve about 30 million people. There are several reasons why outbreaks in individual water systems are not likely to be reported. Many health departments lack the legislative authority or sufficient resources to conduct water quality surveillance programs for individual water systems or to adequately investigate sporadic reports of disease in rural areas. In many cases illness occurring in rural areas is not recognized as possibly transmitted by contaminated water because (1) the illness

is mild and medical attention is not sought and (2) if medical attention is obtained few individuals or only family members are affected and a common source is not considered or person-toperson transmission is assumed. Reportable diseases such as typhoid are likely, however, to be investigated and in many cases are found to be waterborne.

Six hundred and three waterborne outbreaks were reported in community water systems, 500 waterborne outbreaks were reported in noncommunity water systems, and 302 waterborne outbreaks were reported in individual water systems during this 61 year period (Table 1). Twenty-two percent of the outbreaks and two percent of the cases of illness occurred in individual water systems (Figure 2). Outbreaks in individual water systems do not account for much of the reported waterborne disease in the United States, but a sufficient number of outbreaks have been reported so that the analysis of the causes and etiologies of these outbreaks can be used for establishing surveillance and control strategies for prevention of waterborne diseases from these systems.

An average of five outbreaks per year were reported in individual water systems during 1920-80; more outbreaks (24) were reported in 1941 than any other year of this period (Figure 3). Most of the outbreaks in individual water systems were small, affecting primarily members of the same family. Only nine percent of these outbreaks resulted in more than 50 ill individuals (Table 2). The larger outbreaks were primarily the result of widespread contamination of groundwater aquifers. There were 67 outbreaks in which a death occurred, and most deaths (80 percent) occurred during 1920-40. No deaths were reported in individual water system outbreaks during 1971-80.

An etiologic agent was identified in 84 percent of the outbreaks in individual water systems with the remaining outbreaks categorized as acute gastroentestinal illness characterized by symptoms including abdominal cramps, nausea, vomiting, and diarrhea occurring 12 to 48 hours after consumption of water (Table 3). S. typhi was the most commonly identified pathogen with some 57 percent of the outbreaks resulting in typhoid fever. Most deaths (90 percent) were associated with waterborne typhoid outbreaks. Although many of the typhoid outbreaks and deaths occurred in the early part of this period, waterborne typhoid has continued to be reported in recent years. Because typhoid fever is a reportable disease with possible severe consequences, it is likely that single cases will be thoroughly investigated and this may be the reason for the large proportion of typhoid outbreaks reported in individual water systems. Most typhoid outbreaks (75 percent) were caused by the consumption of contaminated, untreated groundwater, and the continued occurrence in recent years may be due to a higher residual of carriers among older individuals residing in rural areas with inadequate sewage disposal facilities and inadequately protected or treated water supplies.

Eight percent of the outbreaks in individual water systems resulted in shigellosis. The symptoms of shigellosis are relatively similar to salmonellosis (diarrhea, abdominal cramps, fever, chills, and vomiting) and clinically these enteric infections are usually indistinguishable. However, shigella infection more frequently produces bloody stools and rectal pain. Approximately seven percent of the outbreaks resulted in hepatitis A, a viral disease with symptons of nausea, vomiting, muscle aches, and jaundice that occur 15 to 45 days after exposure. The diagnosis can be made by history, physical examination, tests of liver function, and serologic studies. Hepatitis A outbreaks are often not

recognized because the long incubation period obscures the relationship between illness and exposure. Most outbreaks of shigellosis (74 percent) and hepatitis A (59 percent) were caused by consumption of contaminated, untreated groundwater. Eight deaths were associated with shigella outbreaks and one death with hepatitis A outbreaks.

Five percent of the outbreaks were chemical poisonings caused by arsenic, pesticides, selenium, nitrates, lead, polychlorinated biphenyl, phenols, gasoline, and copper (Table 4). Six outbreaks occurred as the result of accidental or inadvertent contamination of groundwater with phenols, polychlorinated biphenyls, gasoline, and pesticides; four outbreaks occurred due to natural groundwater contamination by arsenic, selenium, and nitrates; two outbreaks resulted from deliberate contamination of wells with arsenic. The remaining chemical poisonings occurred because of backsiphonage, corrosion of plumbing, and contaminated storage facilities.

There appears to be a seasonal distribution of outbreaks in individual water systems with most outbreaks occurring during June, July, August, and September (Figure 4). This seasonal distribution is evident for outbreaks caused by use of both contaminated, untreated surface water (Figure 5) and well water (Figure 6). The water supplies affected were primarily home or farm supplies, and this suggests there is increased contamination of individual water systems during the summer months. Increased water demand in the summer may be a contributing factor.

The major cause (55 percent) of outbreaks in individual water systems was use of contaminated, untreated well water (Figure 7). Use of contaminated,

untreated surface water was responsible for 16 percent of the outbreaks, and use of contaminated, untreated springs was responsible for 11 percent of the outbreaks. Miscellaneous and undetermined causes of contamination were responsible for 15 percent of the outbreaks. Because so few individual water systems provide treatment or have elaborate distribution systems, inadequate treatment and contamination of distribution and storage facilities were minor causes of outbreaks (three percent).

Specific sources of contamination were examined within each of these water supply deficiencies (Tables 5 to 10). One hundred sixty-seven outbreaks occurred in well water systems used without treatment (Table 5). Overflow or seepage of sewage, primarily from septic tanks or cesspools, was responsible for 38 percent of the outbreaks caused by use of contaminated, untreated well water. This includes outbreaks where contaminants travelled through limestone or fissured rock. Six percent of the outbreaks in untreated well water systems were caused by chemical contamination. There were insufficient data to establish a source of contamination for 24 percent of the outbreaks in well water systems emphasizing the need for better engineering investigations if groundwater contamination problems are to be understood. In addition to using untreated well water, individuals use surface water and spring water with no treatment, and most of the outbreaks caused by contaminated, untreated surface water (58 percent) and spring water (61 percent) also had insufficient data to establish the source of contamination.

Fourteen outbreaks and 186 cases of illness in individual water systems were reported by Ohio during this period. Thirteen of these outbreaks resulting in 176 cases of typhoid fever occurred in the 1930's and early 1940's and were

caused by use of contaminated, untreated wells or springs. The most recent Ohio outbreak occurred in 1980 and involved ten hikers who became ill with gastroenteritis after consuming untreated stream water.

Acknowledgements

This report would not have been possible without the dedicated epidemiologists, engineers, sanitarians, nurses, microbiologists, and chemists in local and state public health agencies who uncover and investigate outbreaks. Knowledge obtained from their investigations not only helps correct deficiencies in water systems during an outbreak but also provides the documentation which can assist public health officials in the development of surveillance programs to prevent the occurrence of similar outbreaks. Special appreciation is expressed to our professional colleagues at CDC and EPA and to Lon Winchester for his assistance in typing and editing this manuscript.

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TABLE 1

Waterborne Outbreaks in the United States
1920-80

Type of Water System	Outbreaks	Illnesses	Deaths
Community	603	337,354	767
Noncommunity	500	42,089	92
Individual	302	6,701	224
Total	1,405	386,144	1,084

TABLE 2

Frequency of Occurrence and Size of Waterborne Outbreaks
in Individual Water Systems
1920–80

Outbreak Size (cases of illness)	Number of Outbreaks
1 - 2	3
2 - 5	95
6 - 10	81
11 - 25	63
26 - 50	34
51 - 100	16
101 - 500	9
501 - 700	1

TABLE 3

Etiology of Waterborne Outbreaks in Individual Water Systems
1920-80

Disease	Outbreaks	Illness	Deaths
Typhoid Fever	173	2,799	202
Gastroenteritis, unidentified etiology	47	2,351	2
Shigellosis	23	833	8
Hepatitis A	22	406	1
Chemical Poisoning	16	103	9
Giardiasis	5	72	0
Salmonellosis	5	35	0
Amebiasis	4	23	1
Paratyphoid Fever	3	17	0
Tularemia	2	6	0
Campylobacter diarrhea	1	21	0
Toxigenic *E. coli* diarrhea	1	35	1
Totals	302	6,701	224

TABLE 4

Chemicals Responsible for Waterborne Outbreaks
in Individual Water Systems
1920-80

Chemical	Outbreaks	Illness
Arsenic	4	25
Pesticides	3	19
Selenium	2	7
Nitrates	2	2
Lead	1	2
PCB	1	20
Phenols	1	17
Gasoline	1	10
Copper	1	1
Totals	14	103

TABLE 5

Outbreaks in Individual Water Systems Caused by
Use of Contaminated, Untreated Wells
1920-80

Deficiency	Outbreaks	Illnesses
1. Overflow or seepage of sewage	52	675
2. Surface runoff	34	824
3. Creviced limestone, fissured rock	12	660
4. Chemical contamination	10	68
5. Improper construction	9	141
6. Flooding	5	211
7. Contamination by stream or river	3	48
8. Animal in well	2	19
9. Insufficient data	40	413
Totals	167	3,059

TABLE 6

Outbreaks in Individual Water Systems Caused by Use of Contaminated, Untreated Surface Water 1920-80

Deficiency	Outbreaks	Illnesses
1. Contamination of watershed	12	257
2. Overflow of sewage near water intake	5	87
3. Use of surface water for supplemental source	2	115
4. Heavy rains, flooding	1	77
5. Insufficient data	28	436
Totals	48	972

TABLE 7

Outbreaks in Individual Water Systems Caused by
Use of Contaminated, Untreated Springs
1920-80

Deficiency	Outbreaks	Illnesses
1. Surface runoff	7	75
2. Overflow or seepage of sewage	5	16
3. Improper construction	1	7
4. Insufficient data	20	415
Totals	33	538

TABLE 8

Outbreaks in Individual Water Systems Caused by Miscellaneous Reasons
1920-80

Deficiency	Outbreaks	Illnesses
1. Use of water not intended for drinking	6	263
2. Contaminated buckets, hoses, tank truck	4	89
3. Ingestion of water while swimming	4	70
4. Contaminated ice	3	1,060
5. Deliberate contamination with chemicals	2	18
6. Contaminated bottled water	1	3
7. Insufficient data	24	536
Totals	44	2,039

TABLE 9

Outbreaks in Individual Water Systems Caused by
Inadequate Treatment
1920-80

Deficiency	Outbreaks	Illnesses
1. Inadequate disinfection	3	50
2. Interruption of disinfection	1	3
3. Inadequate filtration	1	9
Totals	5	62

TABLE 10

Outbreaks in Individual Water Systems Caused by Contamination of Distribution or Storage Facilities 1920-80

Deficiency	Outbreaks	Illnesses
1. Contamination of cistern	3	24
2. Backsiphonage	1	5
3. Corrosion of plumbing	1	2
Totals	5	31

FIGURE 1

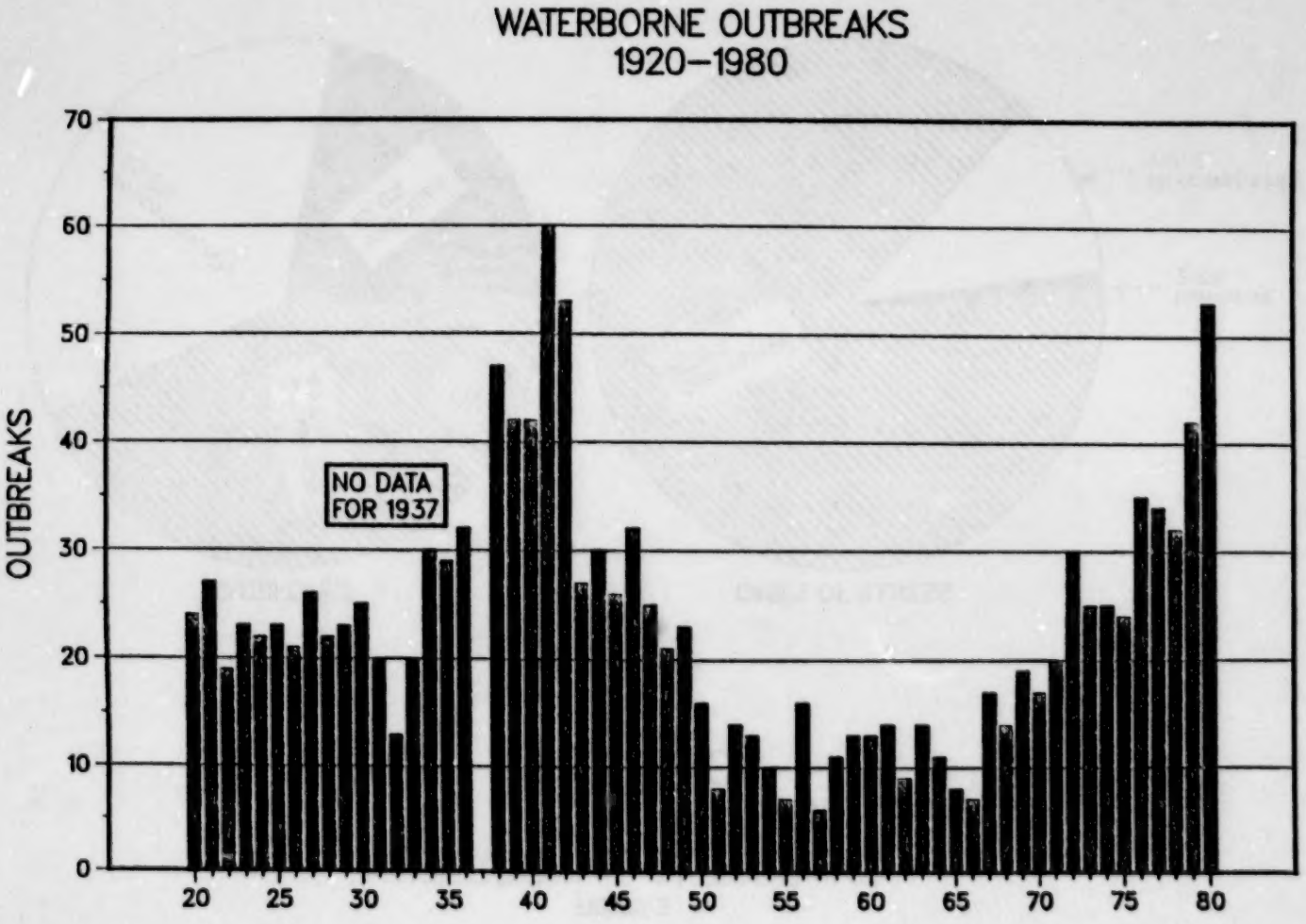

WATERBORNE OUTBREAKS
1920–1980
OUTBREAKS
70
60
50
40
30
20
10
0
NO DATA
FOR 1937
20
25
30
35
40
45
50
55
60
65
70
75
80

FIGURE 2

WATERBORNE OUTBREAKS BY TYPE OF SYSTEM 1920–1980

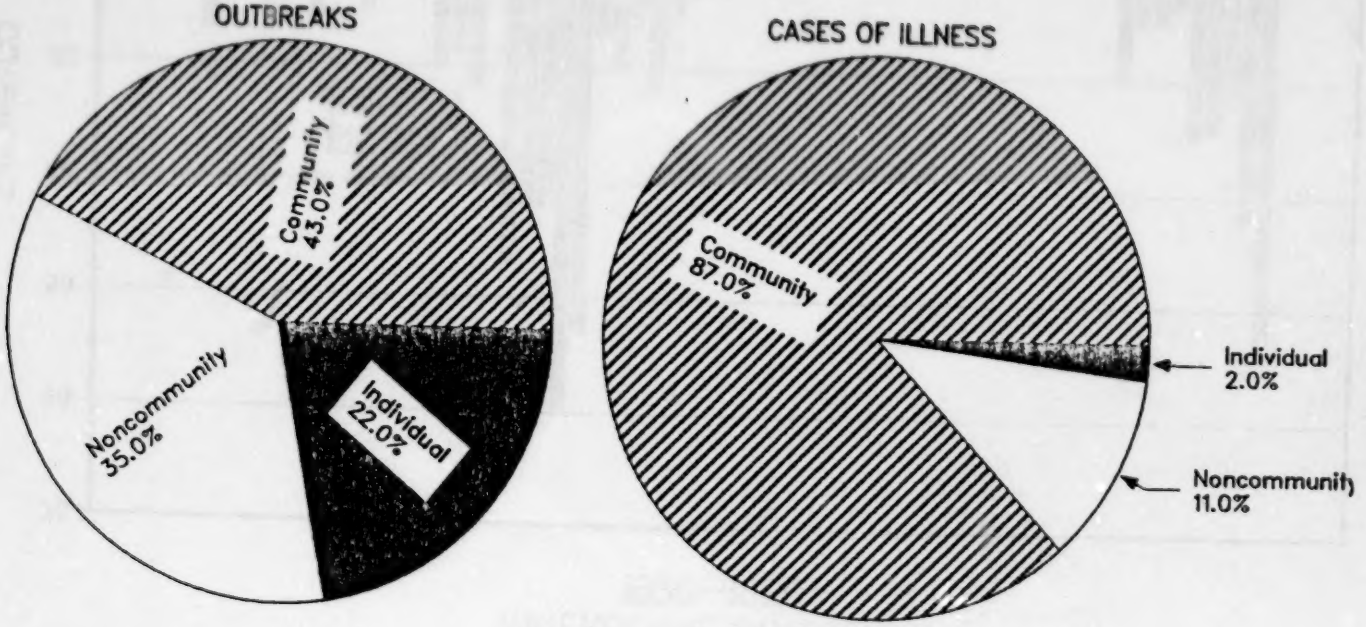


FIGURE 3

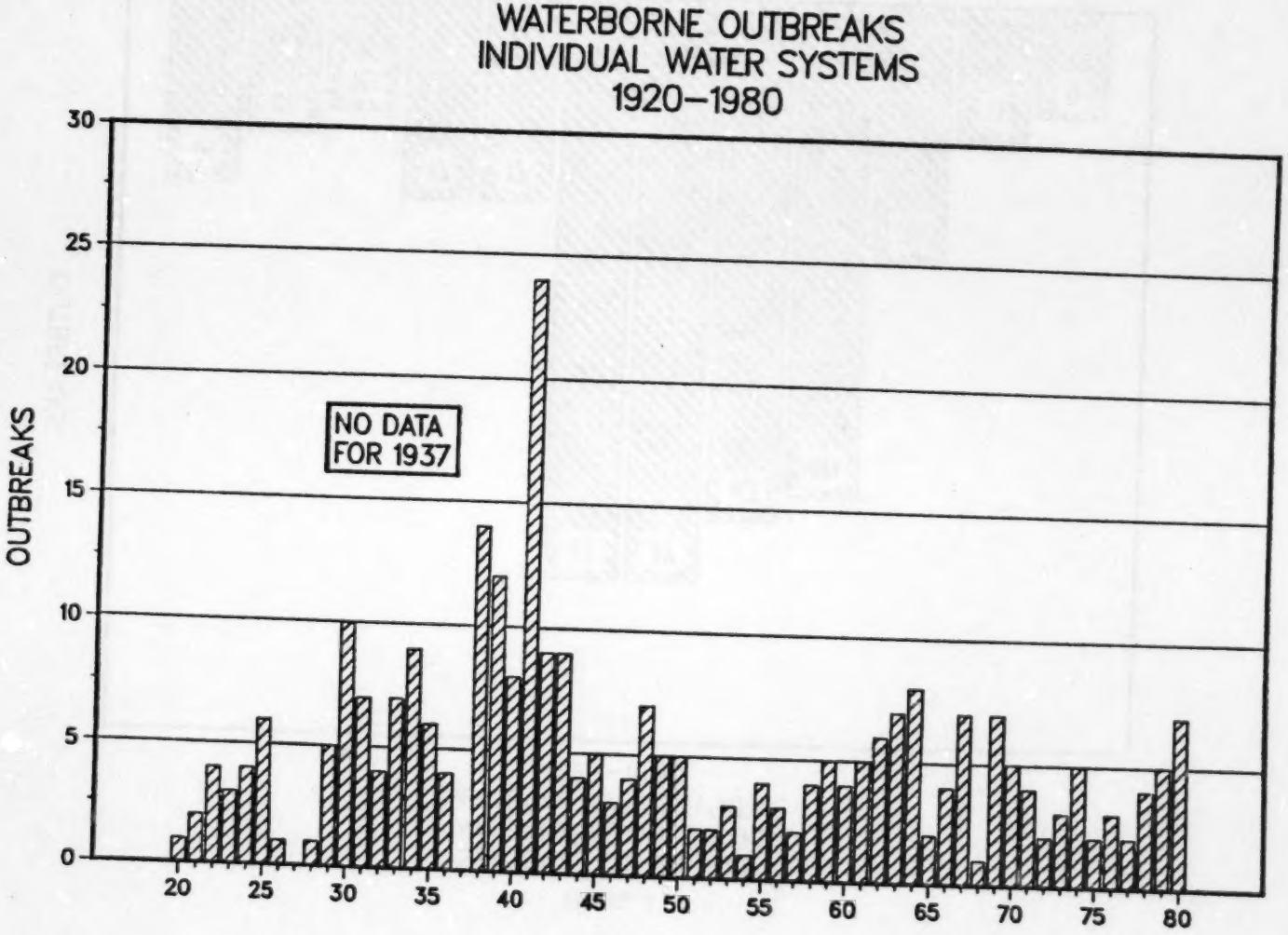

WATERBORNE OUTBREAKS
INDIVIDUAL WATER SYSTEMS
1920–1980
OUTBREAKS
30
25
20
15
10
5
0
NO DATA
FOR 1937
20
25
30
35
40
45
50
55
60
65
70
75
80

FIGURE 4

SEASONAL DISTRIBUTION
WATERBORNE OUTBREAKS
INDIVIDUAL WATER SYSTEMS
1920–1980

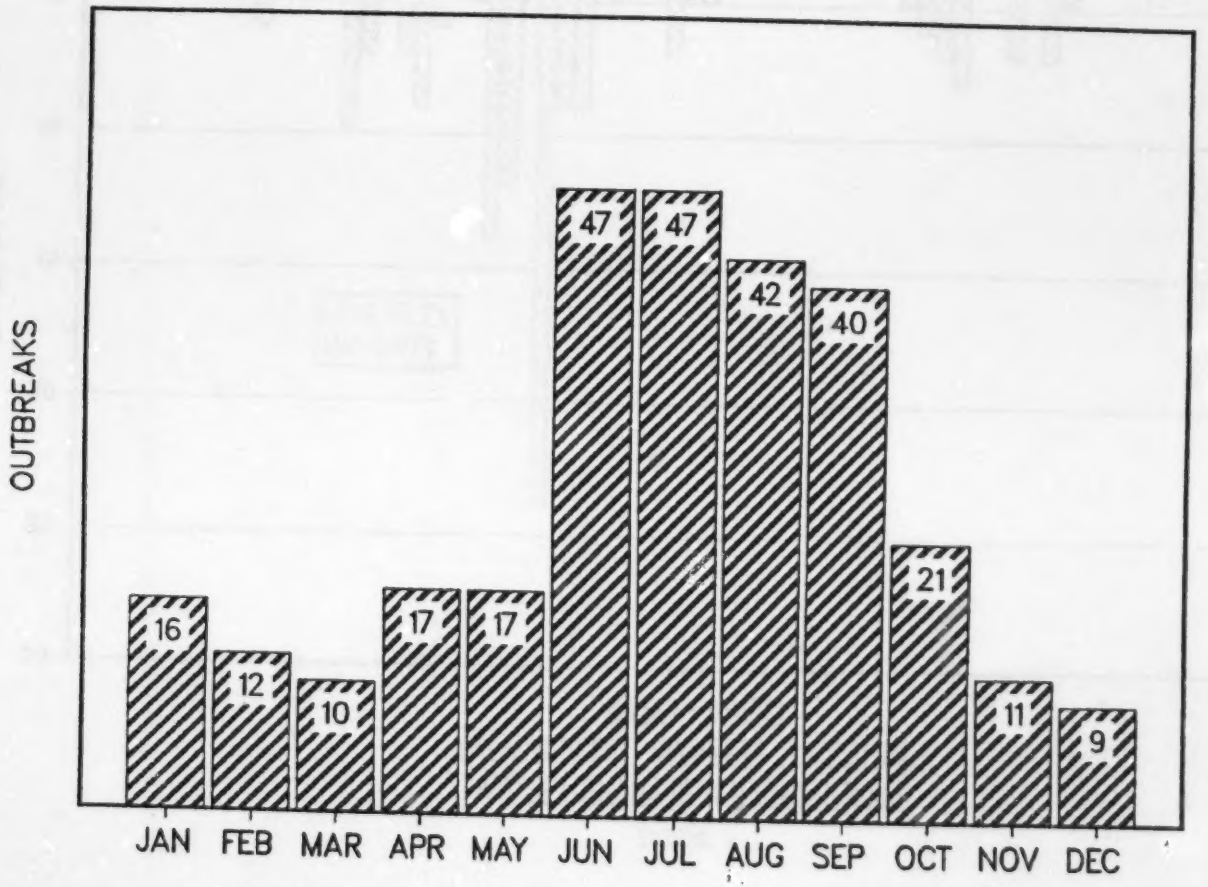


FIGURE 5

SEASONAL DISTRIBUTION
WATERBORNE OUTBREAKS IN INDIVIDUAL WATER SYSTEMS
Untreated Surface Water Systems
1920–1980

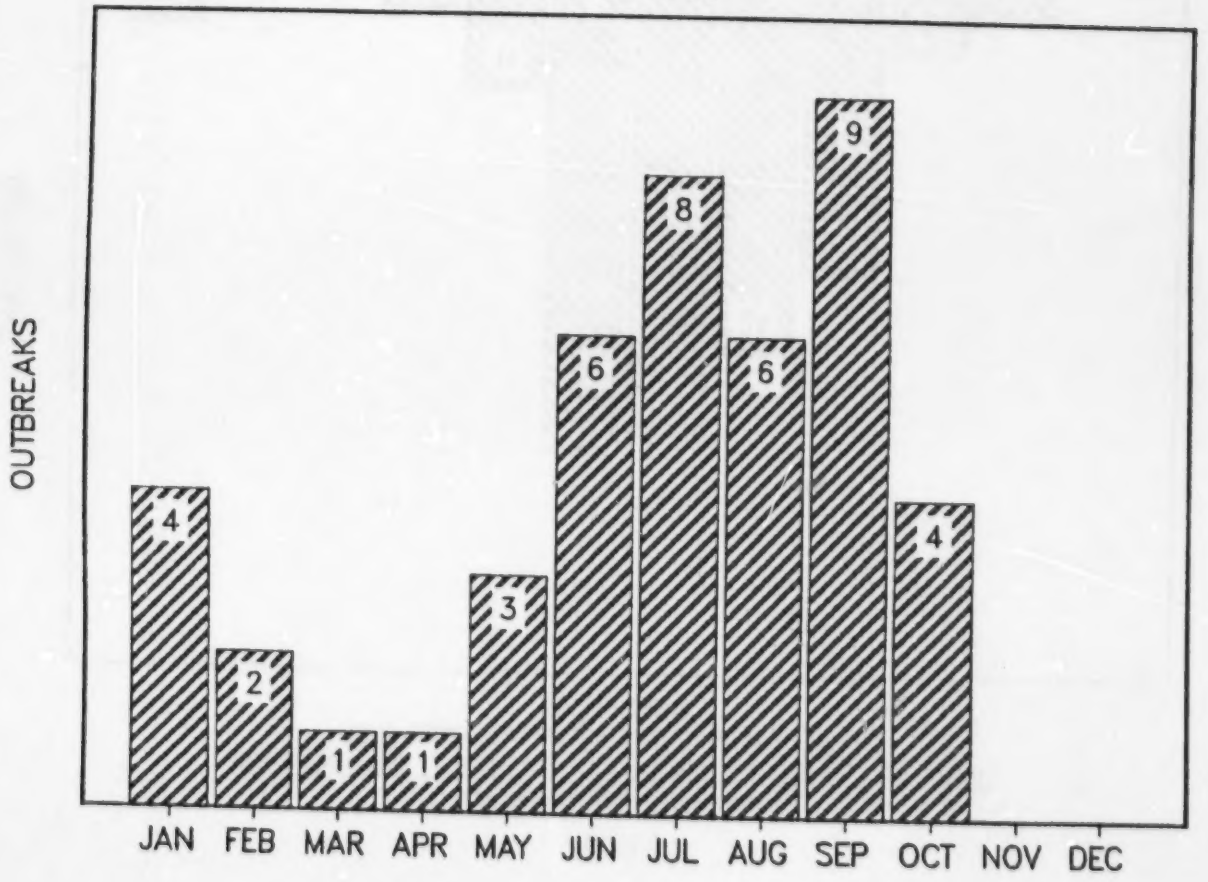


FIGURE 6

SEASONAL DISTRIBUTION
WATERBORNE OUTBREAKS IN INDIVIDUAL WATER SYSTEMS
Untreated Groundwater Systems {Wells}
1920–1980

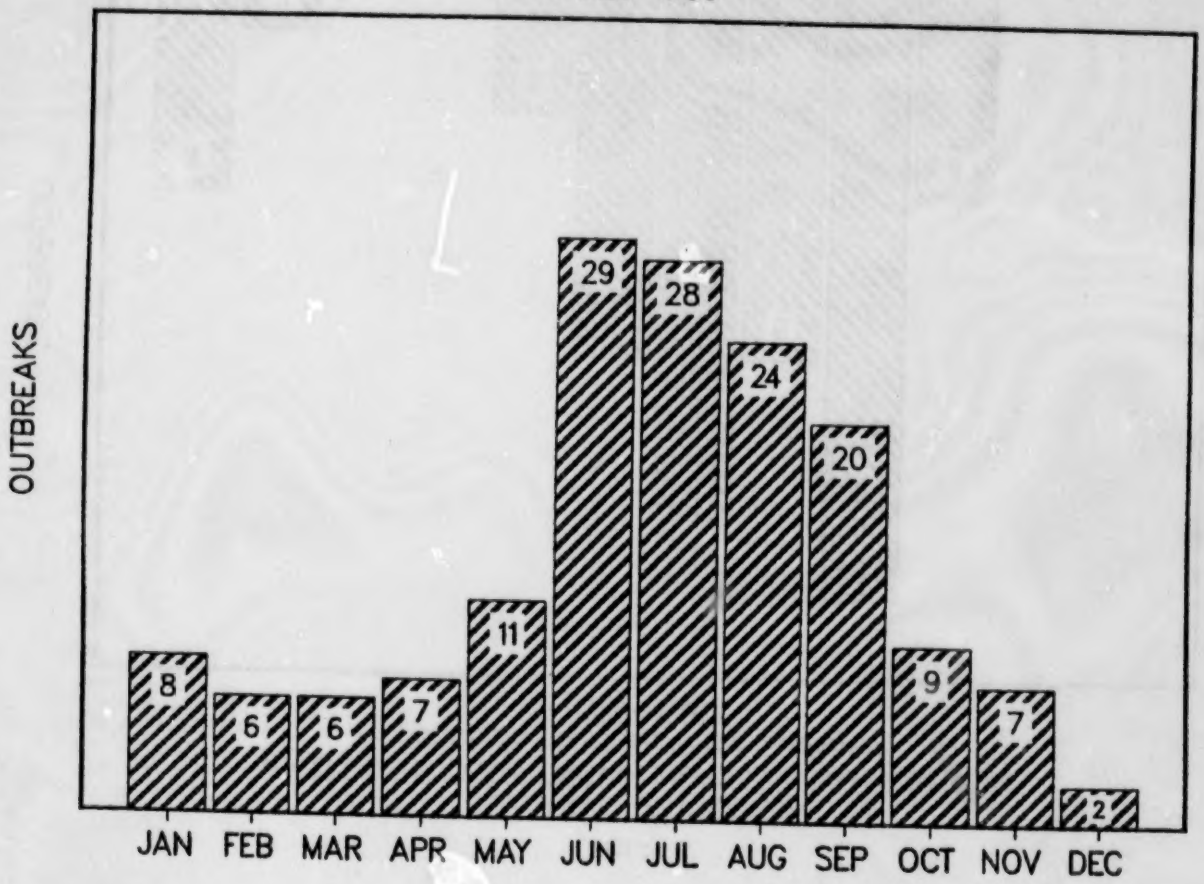
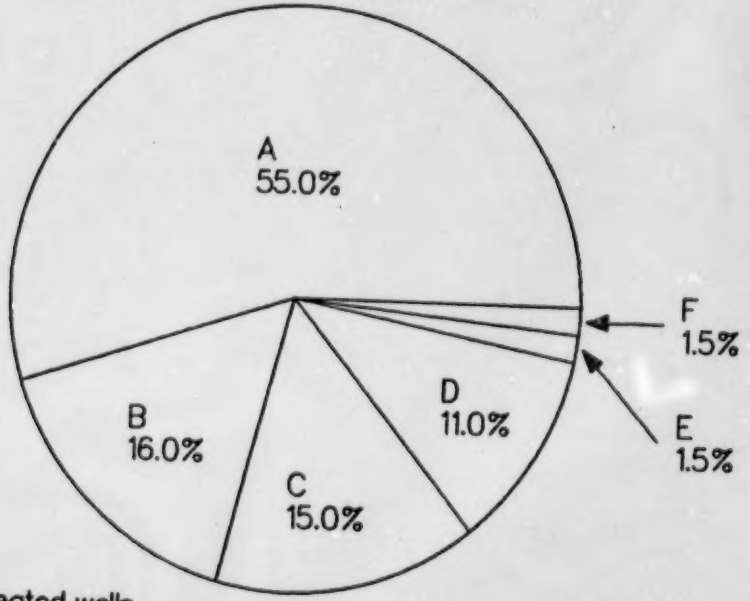


FIGURE 7

CAUSES OF WATERBORNE OUTBREAKS IN INDIVIDUAL WATER SYSTEMS 1920–1980



A. Contaminated, untreated wells
B. Contaminated, untreated surface water
C. Miscellaneous causes
D. Contaminated, untreated springs
E. Distribution deficiencies
F. Treatment deficiencies